WELCOME TO
NASA APPLIED REMOTE SENSING TRAINING (ARSET)
WEBINAR SERIES

INTRODUCTION TO REMOTE SENSING FOR WILDFIRE APPLICATIONS

COURSE DATES: EVERY TUESDAY, MARCH 31- APRIL 28
TIME: 11:30 AM-12:30 PM EST

Course Structure

- One lecture per week – every Tuesday from March 31 to April 28 (11:30 AM – 12:30 PM EST)
- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: http://arset.gsfc.nasa.gov/disasters/webinars/introduction-remote-sensing-wildfire-applications
- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET wildfire webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com
- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

ARSET Wildfire Management

http://arset.gsfc.nasa.gov/eco/webinars/land-management

Course Objectives

- Provide overview of NASA Earth Observations resources available for wildfire applications including:
  - A basic understanding of remote sensing
  - How to access and visualize NASA Earth science data
  - How to use NASA Earth science data, tools, and products for pre and post-burn wildfire applications
- This course is also a prerequisite for advanced ARSET trainings.

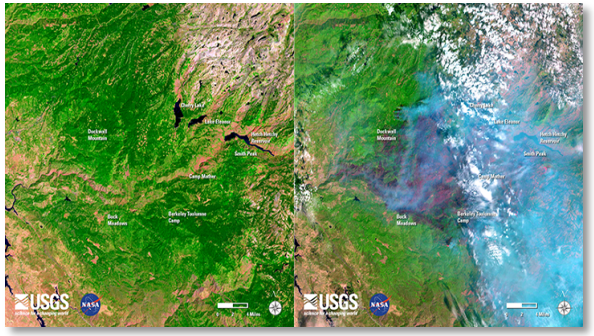
Your Course Instructors

- Cindy Schmidt (ARSET): cynthia.l.schmidt@nasa.gov
- Amber Kuss (ARSET): amberjean.m.kuss@nasa.gov
- Guest Speakers:
  - Keith Weber – Idaho State University (week 3)
  - Tony Guay – USDA Forest Service Remote Sensing Applications Center (week 3)
  - Dale Hamilton – Northwest Nazarene University (week 4)
  - Mark Carroll – NASA Goddard (week 4)
  - Lindsey Harriman and Kelly Lemig – LP DAAC (week 5) lharriman@usgs.gov, klemig@usgs.gov

General inquiries about ARSET: Ana Prados (ARSET) aprados@umbc.edu

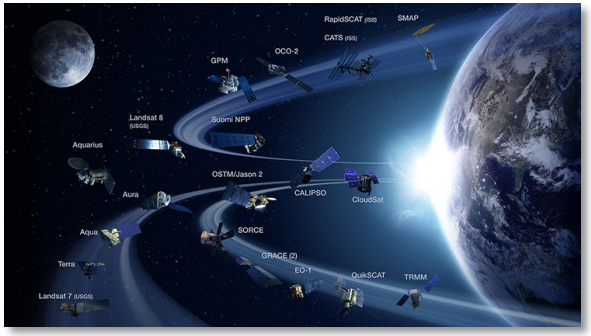
Course Outline

Week 1



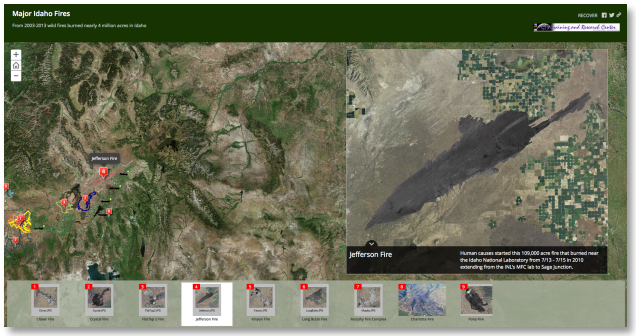
Overview of satellite remote sensing

Week 2



Platforms and sensors for wildfire applications

Week 3

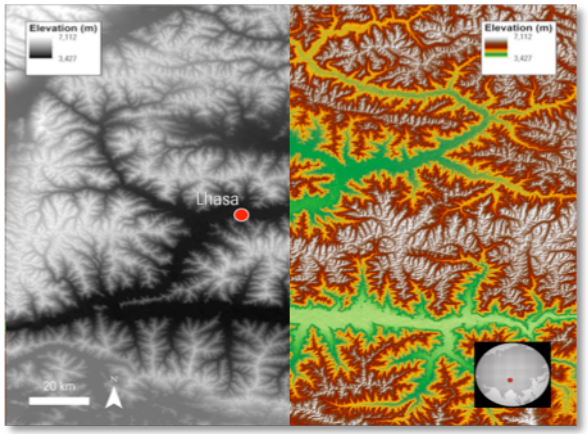


Products for pre and post-wildfire

Week 4

New techniques and technologies

Week 5



Terrain data applications

Week 1 Agenda

- Course structure and objectives
- Overview of ARSET
- Global wildfire issues
- How remote sensing can be used for wildfire applications
- Fundamentals of remote sensing

Applied Remote SEnsing Training (ARSET)

NASA Applied Sciences Capacity Building Program

- **GOAL**: Increase utilization of NASA observational and model data for decision-support through training activities for environmental professionals.
- **Online Trainings**: Live and recorded, 4-6 weeks in length. Include demos on data access
- **In person Trainings**: In a computer lab, 2- 4 days. Large focus on data access
- **Train the Trainers**: Courses and training manuals for those interested in conducting their own remote sensing training.
- **Application Areas:** water resources, disasters, health/air quality, and land management
- http://arset.gsfc.nasa.gov

Accomplishments (2008 – 2014)

- 46 trainings completed
- 2300+ participants worldwide
- 700+ Organizations

NASA Earth Science
Applied Sciences Program Application Areas

Disasters

Ecological Forecasting

Health and Air Quality

Water Resources

Agriculture

Climate

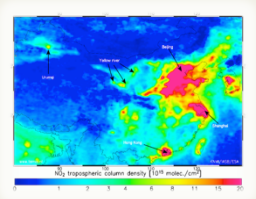
Energy

Oceans

Weather

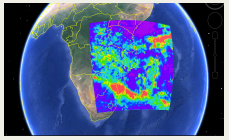
ARSET: Training Focus Areas

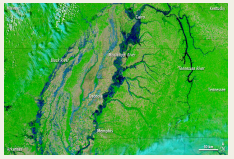
Health (Air Quality)



- 2008 – present
- 33 Trainings
- 1000+ end-users
- Analysis of dust, fires and urban air pollution.
- Long range transport of pollutants
- Satellite and regional air quality model inter-comparisons.
- Support for air quality forecasting and exceptional event analysis

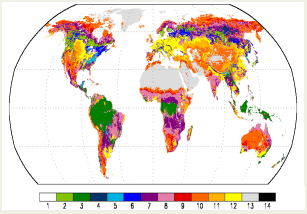
Water Resources and Flood Monitoring





- April 2011 – present
- 11 Trainings
- 1000+ end-users
- Flood/Drought monitoring
- Severe weather and precipitation
- Watershed management
- Climate impacts on water resources
- Snow/ice monitoring
- Evapotranspiration (ET), ground water, soil moisture, and runoff.

Land Management



- Launched in 2014
- 2 Trainings, +300 end-users
- GIS Applications
- Vegetation indices
- Fire products (beginning in 2015)

Train the Trainers (Starting in 2015)

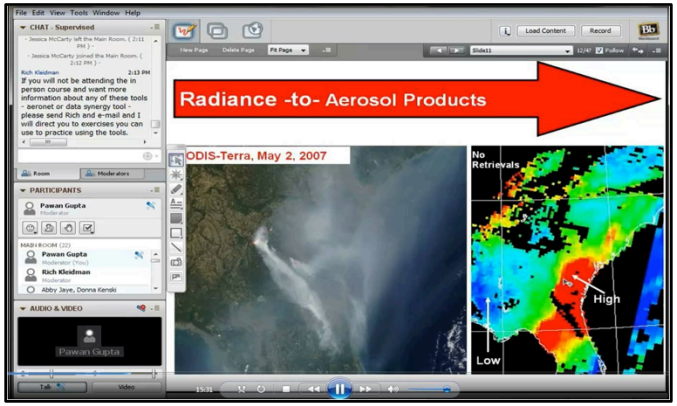
- Courses and guidance on how to design and develop, *YOUR OWN* online and/or computer based remote sensing training
- How to develop effective presentations and exercises.

ARSET: Gradual Learning Approach

Basic Training
Webinars
Hands-on
Assumes no prior knowledge of RS

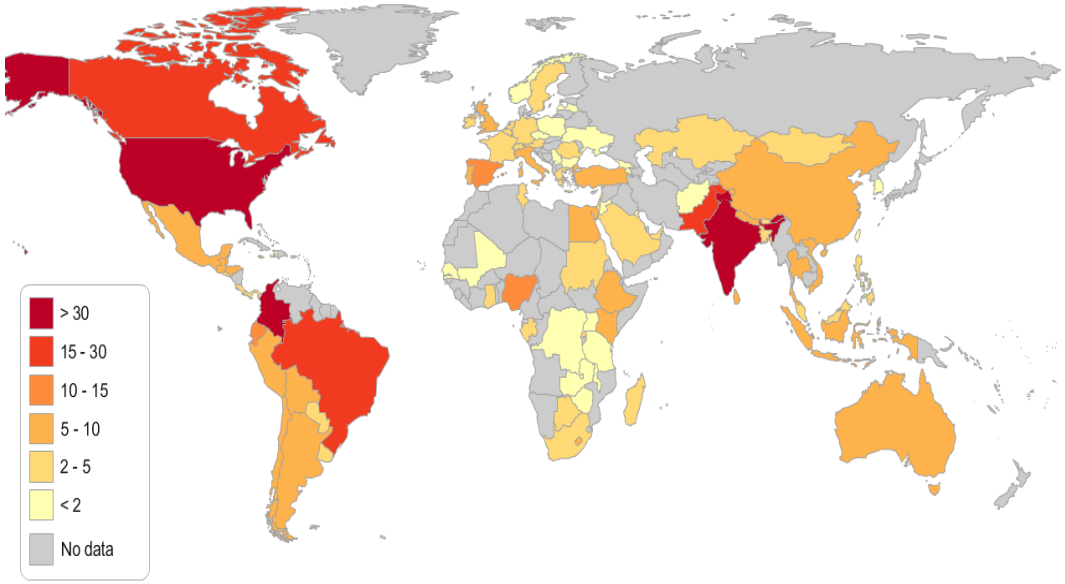
Advanced Training
Hands-on
Webinar course generally required
Focused on a specific application/ problem/Data: for example dust or smoke monitoring in a specific country or region

Online Training



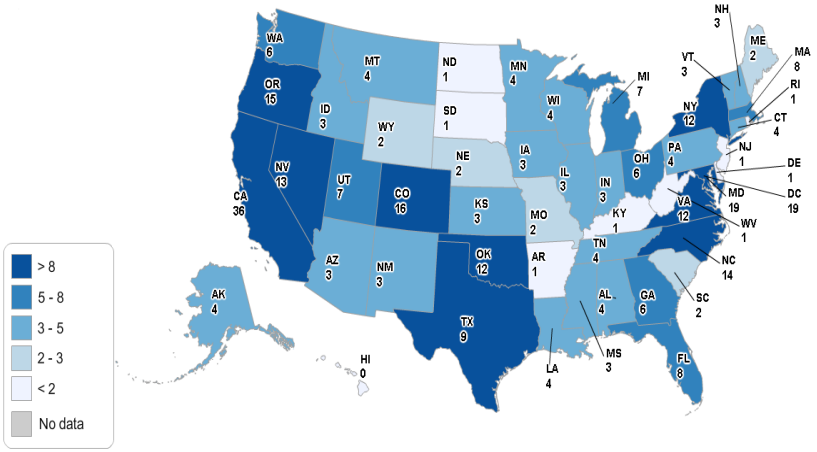
In-Person Training

ARSET: Capacity Building



- 2008 – 2014
  - 46 trainings
  - 2300+ End-users
  - 700+ Organizations

Number of participating organizations per country (above) and per US state (right): Air Quality, Water, Flood, and Land management



Global Wildfire Issues and Remote Sensing Applications

Wildfires: Global Critical Issues

- Loss of human life and property
- Air pollution
- Habitat loss
- Hydrological regime changes and increased risk of landslides
- Increased frequency, duration, and severity due to fire suppression methods and climate change

NASA's Earth Science Research Questions

- How is the global Earth system changing?
- What are the primary causes of change in the Earth System?
- How does the Earth system respond to natural and human-induced changes?
- What are the consequences of changes in the Earth system for human civilization?
- How well can we predict future changes to the Earth system?

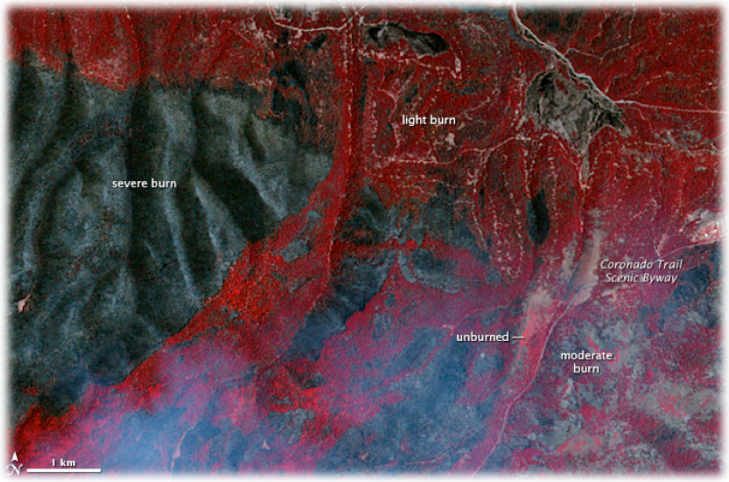
Global Wildfire Management Questions

- What are the pre- and post-burn forest conditions?
- What are the social and economic aspects of wildfires?
- How are land use changes affecting fire regimes?
- How can remote sensing be used to improve fire response measures and pre- and post-burn mitigation efforts?
  - What are the tools managers can use to make these assessments?

Monitoring Wildfire with Remote Sensing

- Pre-fire conditions mapping
  - Fuel moisture
  - Fuel types
  - Topography
- Active fire tracking
  - Surface temperature (thermal infrared technology)
  - Smoke plumes
- Post-burn severity mapping
  - Burned Area

Active Fire Mapping: https://www.servirglobal.net



Wallow Fire Burn Area, 2011, http://earthobservatory.nasa.gov/IOTD/view.php?id=51204

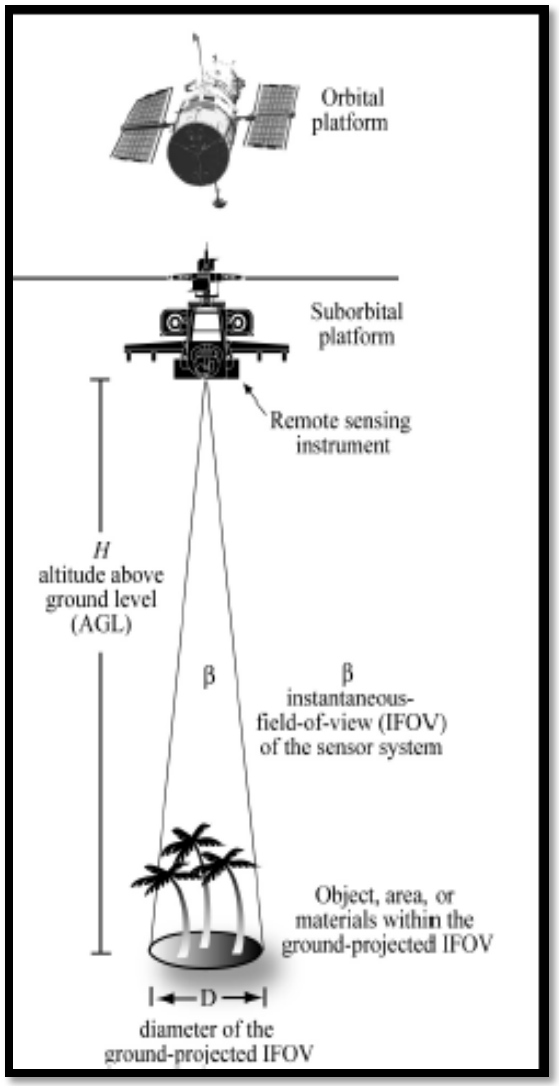
Fundamentals of Remote Sensing

What is Remote Sensing?

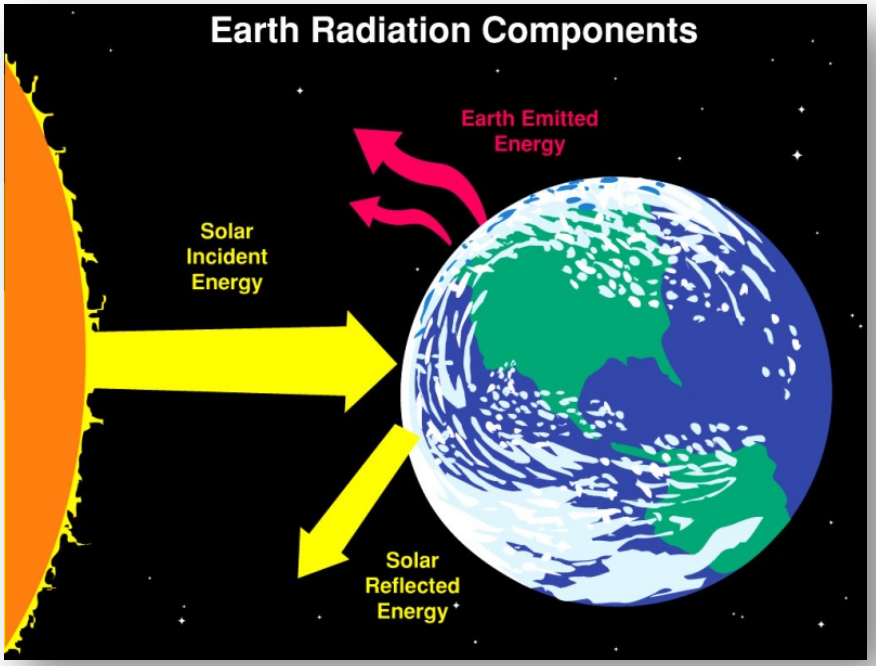
Measurement of a quantity associated with an object by a device not in direct contact with the object

- The most useful platform depends on the application.
- What information? How much detail?
- How frequent?

Satellite Remote Sensing

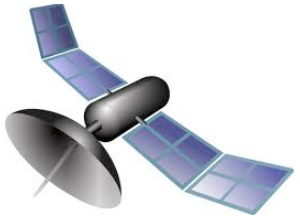


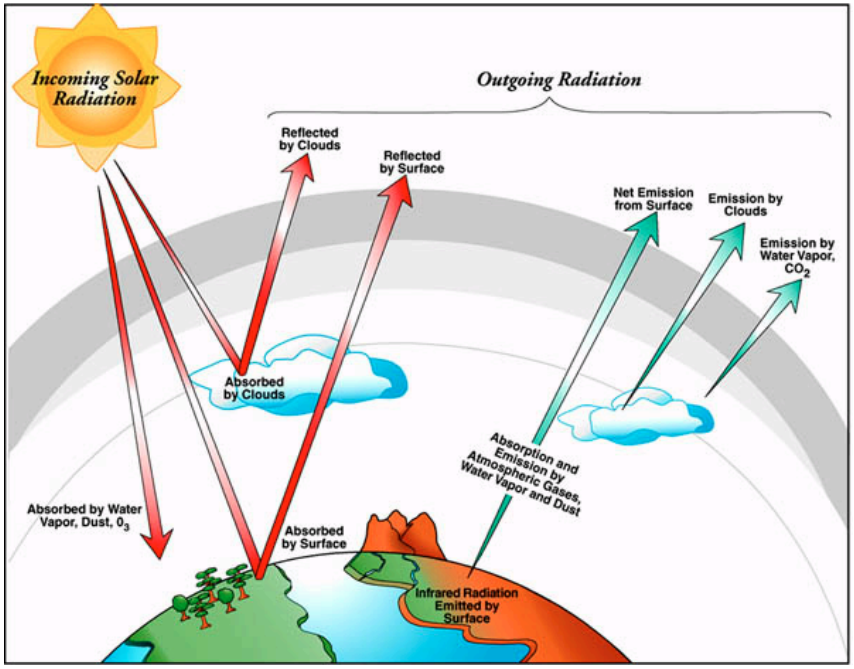
Satellites carry instruments or sensors which **measure electromagnetic radiation** coming from the earth-atmosphere system



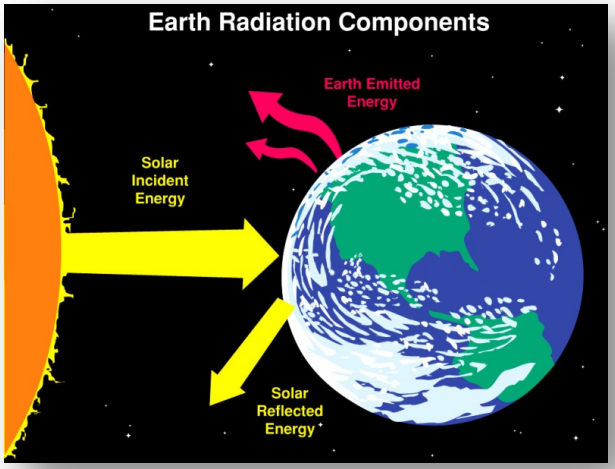
Satellite Remote Sensing

- The intensity of reflected and emitted radiation to space is influenced by the surface and atmospheric conditions.
- Thus, satellite measurements contain information about the surface and atmospheric conditions.



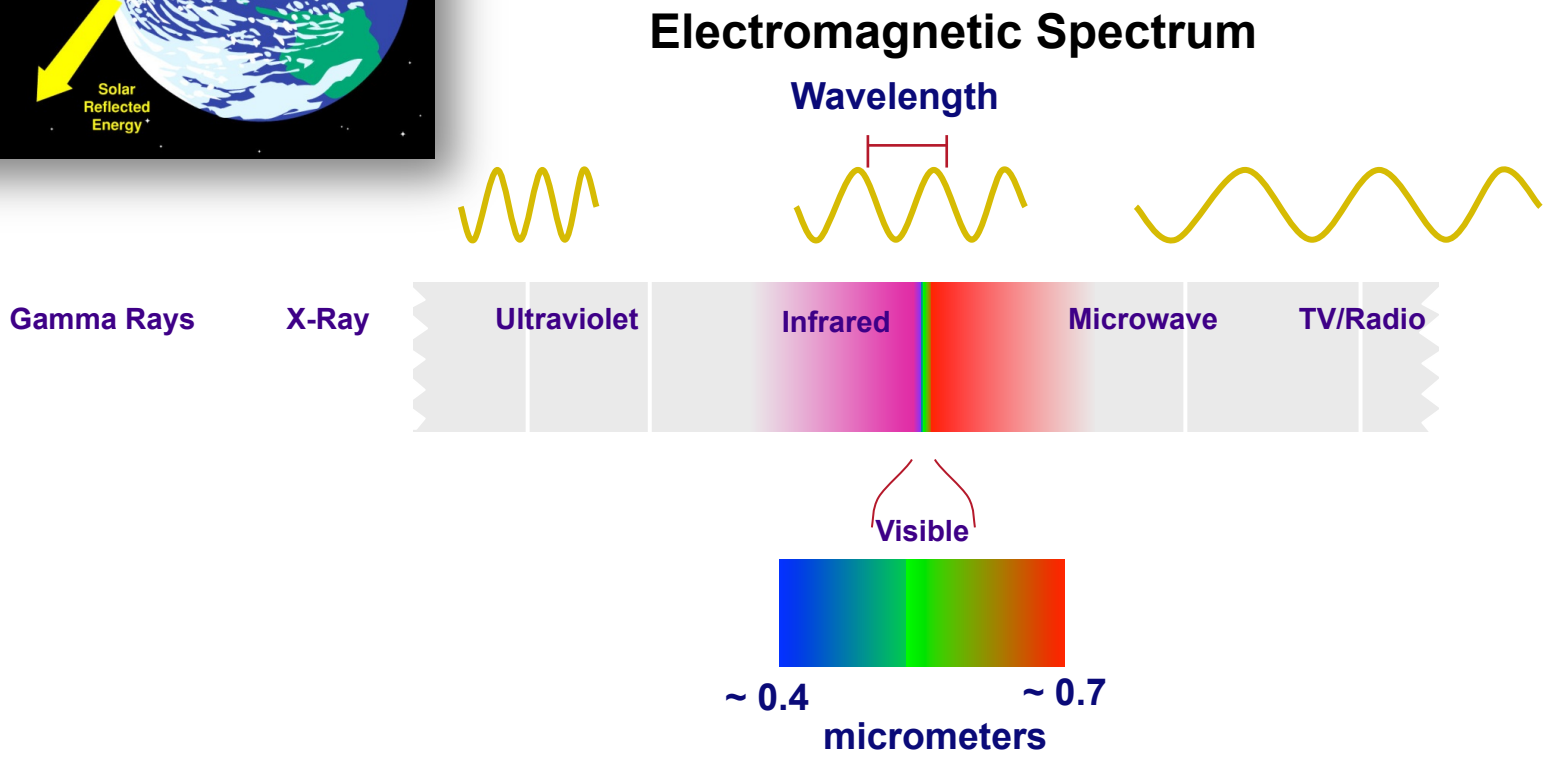


Electromagnetic Radiation

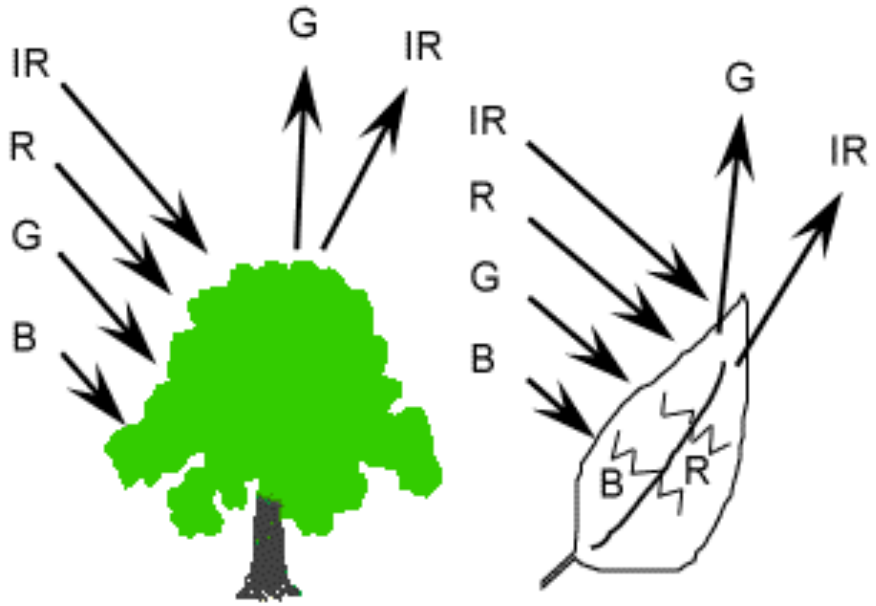


Earth-Ocean-Land-Atmosphere System :

- Reflects solar radiation back to space
- Emits Infrared and Microwave radiation to space



Electromagnetic Energy

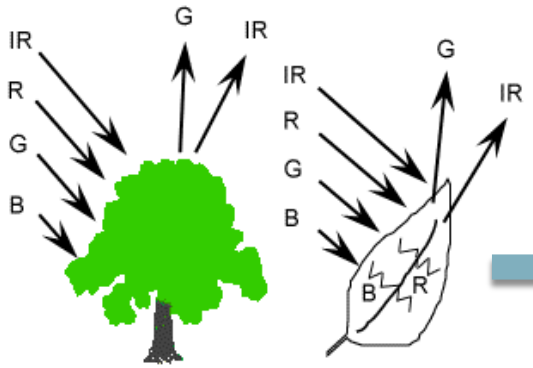


Example: Healthy, green vegetation absorbs Blue and Red wavelengths and reflects Green and Infrared

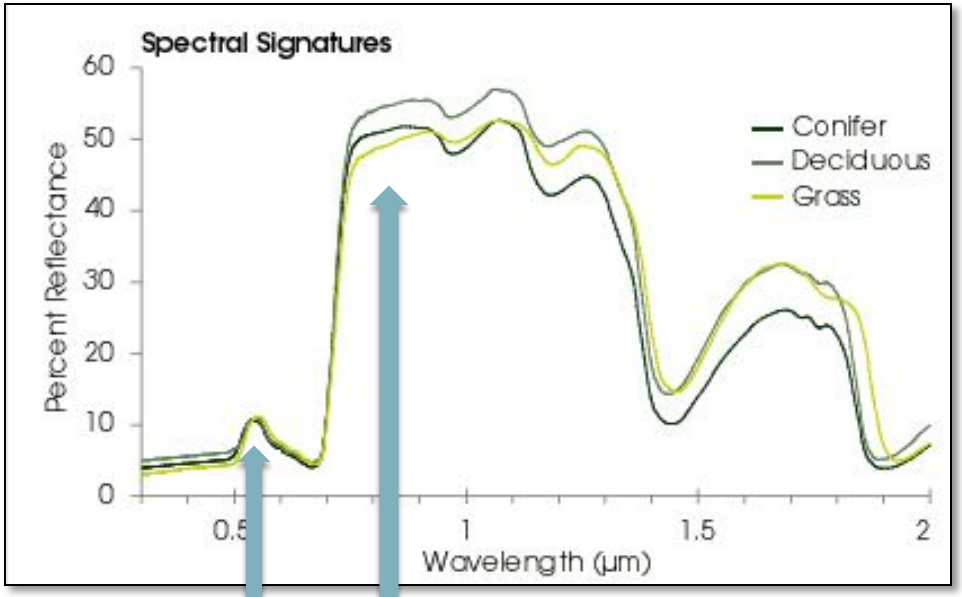
That's why we see healthy vegetation as green

Spectral Signatures

- Every kind of surface has it's own spectral signature
- Going back to the healthy vegetation example….

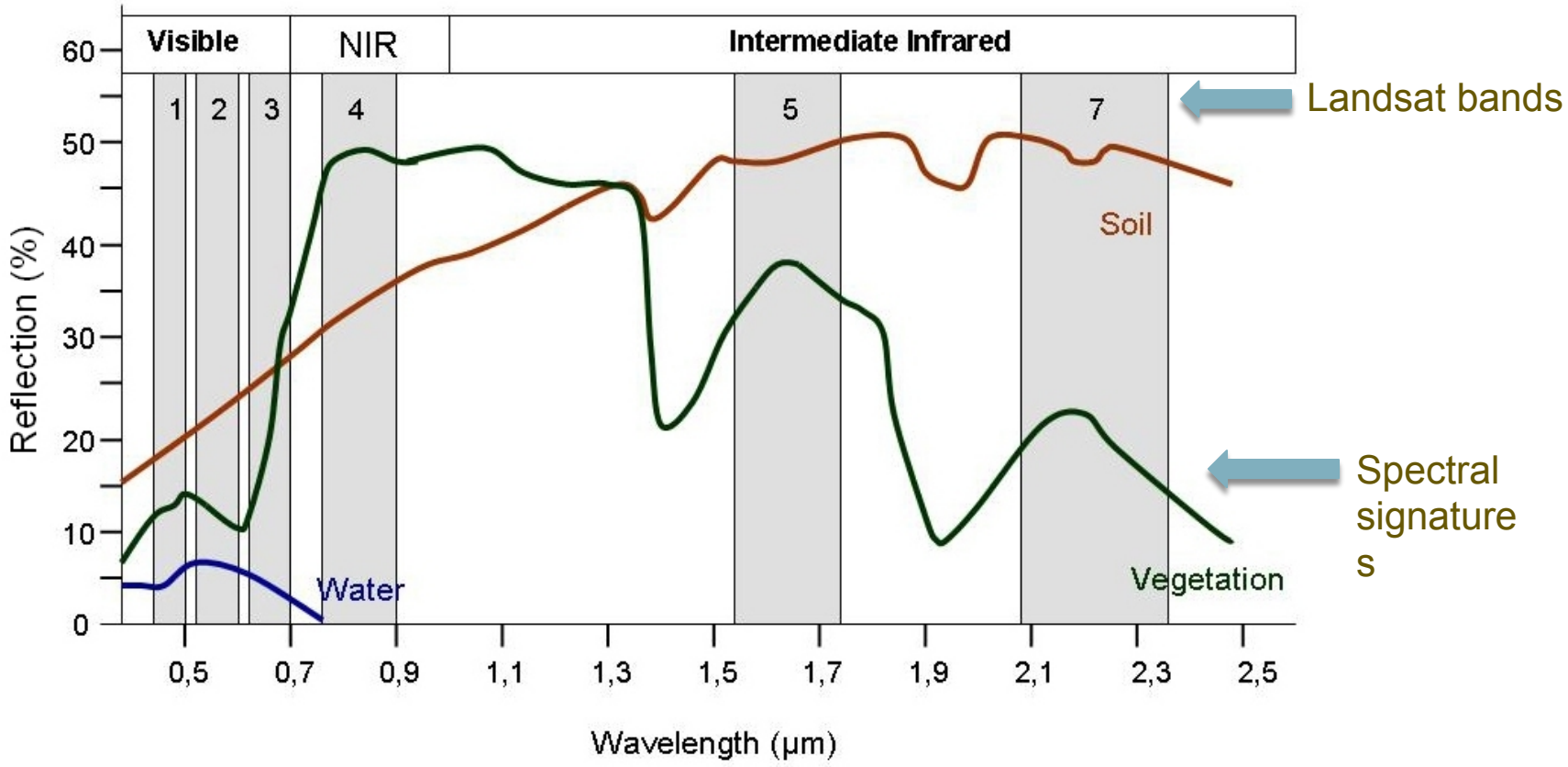


Spectral Signature



Spectral Signatures in Imagery

- Remotely sensed imagery acquires information in different wavelengths, representing different parts of the Electromagnetic Spectrum

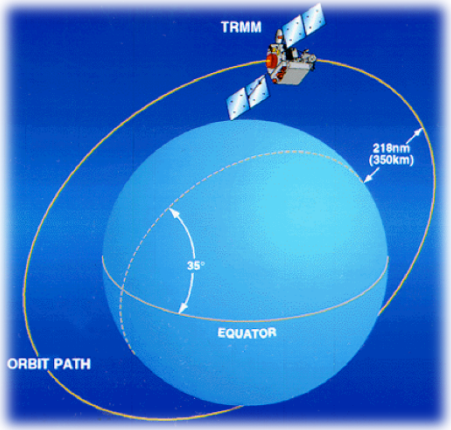


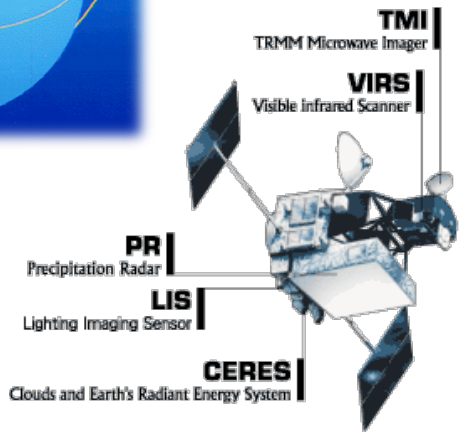
Satellite Remote Sensing Observations: What to Know

- Instruments/sensors and types
- Types of satellite orbits around the Earth

These affect the spatial resolution, the temporal resolution, and the spatial coverage

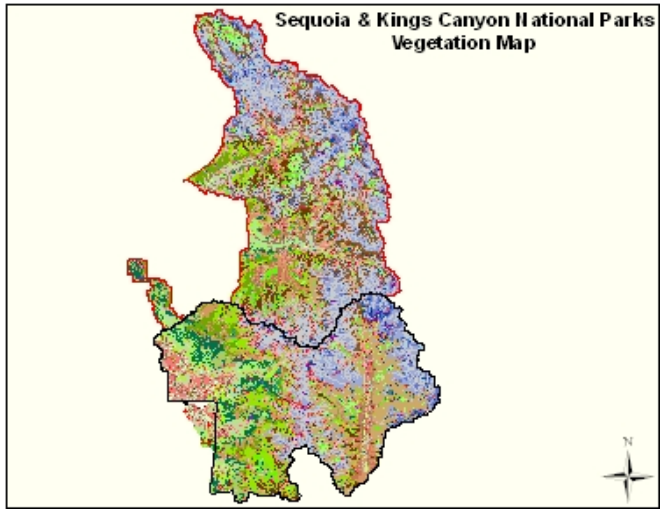
- Spatial and temporal coverage
- Geophysical quantities derived from the measurements
- Quality and accuracy of the retrieved quantity
  - Availability, access, format
  - Applications and usage

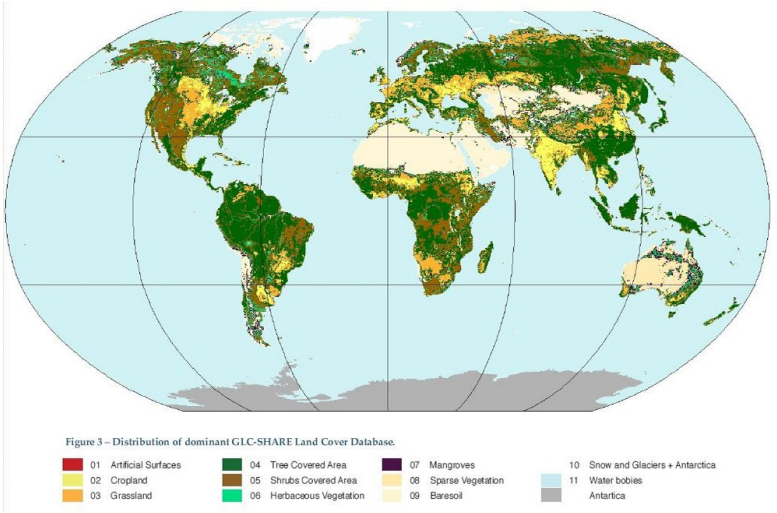




Remote Sensing Observations: Advantages

- Provide information where there are no ground-based measurements
- Provide globally consistent observations
- Provide data at specified date/time
- Cost effective when compared to field-based campaigns





Remote Sensing Observations: Disadvantages

- Spatial Resolution Limitations
  - Does not provide high level of detail at the ground level
  - Cannot detect landcover under canopy
- Ground based-measurements such as US Forest Service Forest Inventory Analysis (FIA) can provide detailed and fine-scaled information

Satellite Sensors

Satellite Sensors

Type of Sensors

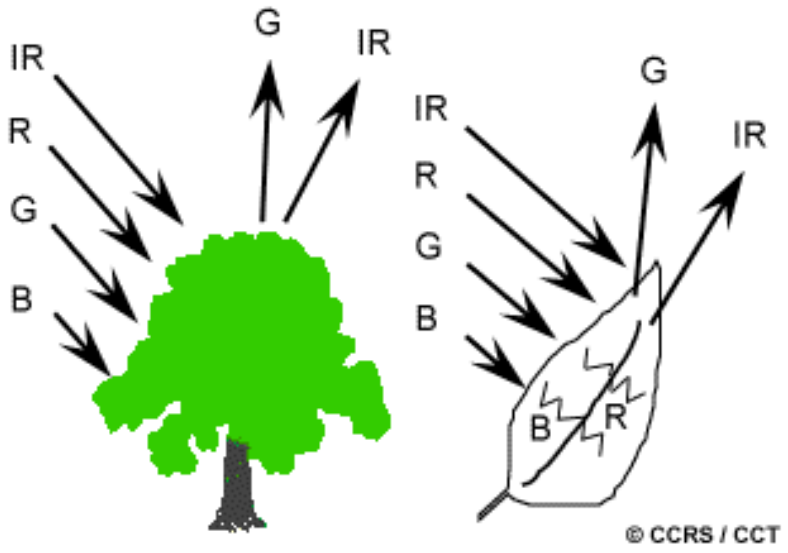
Spectral Resolution

Radiometric Resolution

Spatial Resolution

Satellite Sensors

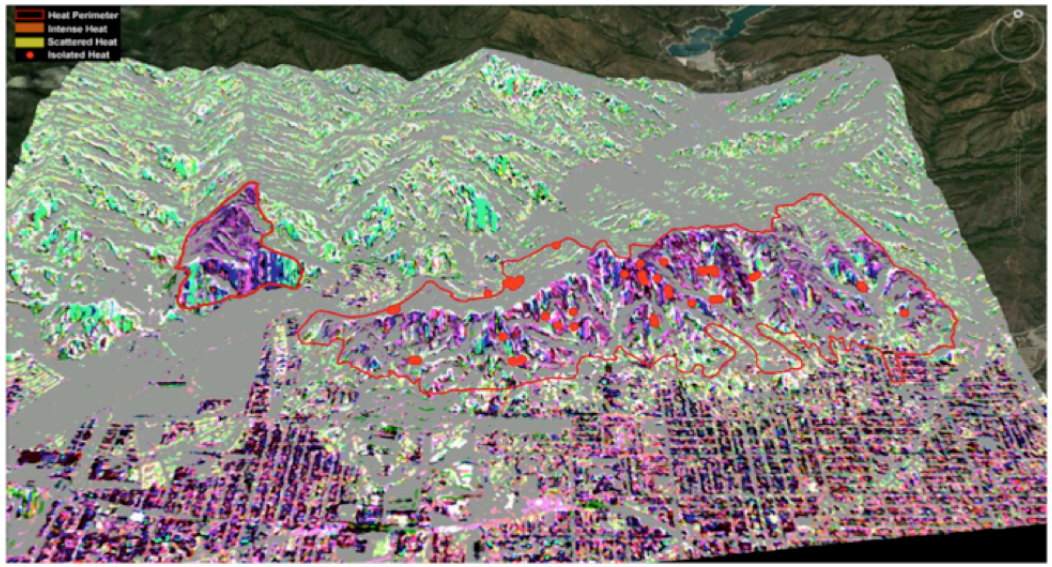
- **Passive** remote sensors measure radiant energy reflected or emitted by the Earth-atmosphere system
  - Examples: Landsat, MODIS



Landsat image of San Francisco Bay Area

Satellite Sensors

- **Active** remote sensors ‘throw’ beams of radiation on the earth-atmosphere system and measure ‘back-scattered’ radiation
  - The back-scattered radiation is converted to geophysical quantities
- Advantages:
  - Can be used day or night
  - Can penetrate cloud cover
- Disadvantages:
  - Challenging to process
  - Some available only from aircraft
- Examples: Radar, LIDAR



Map of fire damage (purple area outlined by red) produced by adapting a change detection technique to UAVSAR L-band polarimetric data. Outlined areas are the 2013 Madre fire (left) and the 2014 Colby fire (right); wildfire hot spots indicated by red dots (US Forest Service, National Infrared Operations).

Spatial and Temporal Resolution of Satellite Measurements

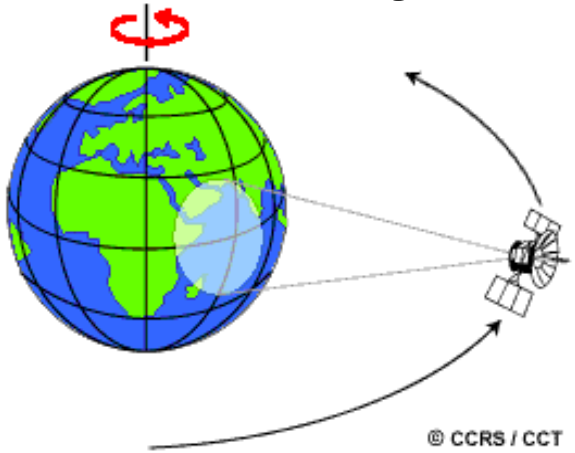
- Depends on the satellite orbit configuration and sensor design

- **Temporal resolution:**
  - How frequently a satellite observes the same area of the earth

- **Spatial Resolution:**
  - Decided by its pixel size -- pixel is the smallest unit measured by a sensor

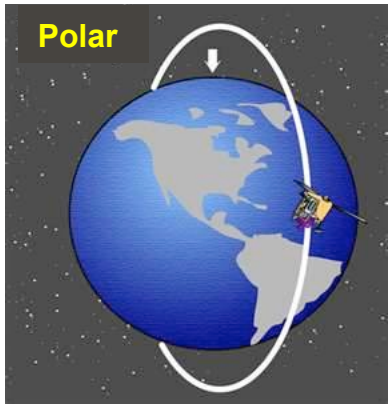
Types of Satellite Orbits

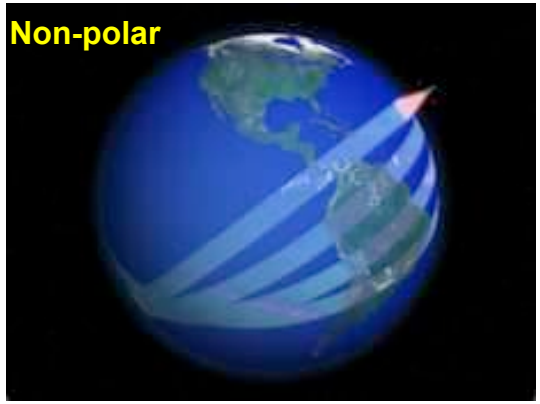
Geostationary orbit



- Satellite is at ~36,000 km above earth at equator. Same rotation period as earth's. Appears 'fixed' in space.
  - Frequent measurements
  - Limited spatial coverage
- Examples:
  - Weather or communications satellites

Low Earth Orbit (LEO)





- Circular orbit constantly moving relative to the Earth at 160-2000 km. Can be in Polar or non-polar orbit
  - Less frequent measurements
  - Large (global) spatial coverage
- Polar orbit examples: Landsat or Terra satellites

Spatial Resolution

- Spatial resolution refers to the detail discernable in an image by a pixel

Sensor	Spatial Resolution
Digital Globe (and others)	1-4 m
Landsat	30 m
MODIS	250 m-1km

Spatial Resolution

1 meter | 10 meter | 30 meter

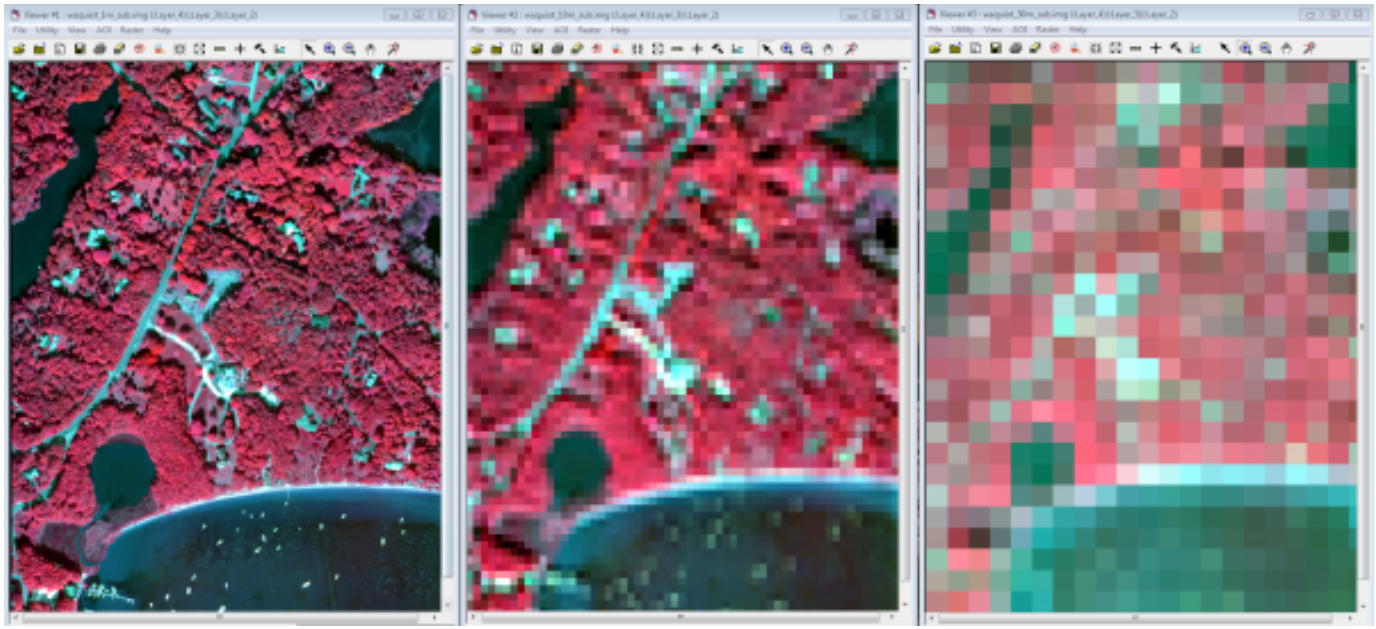
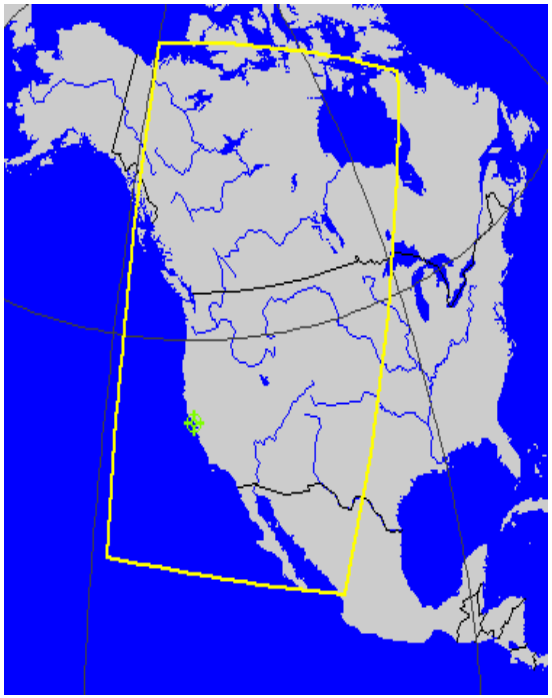


Image courtesy of www.csc.noaa.gov

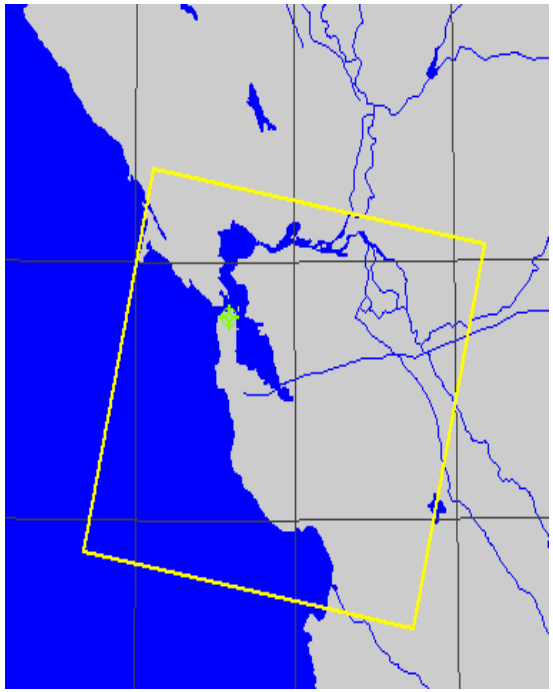
- BUT….there is a tradeoff between spatial resolution and spatial extent!

Spatial Extent

- Generally, the higher the spatial resolution the less area is covered by a single image



MODIS (1 km)

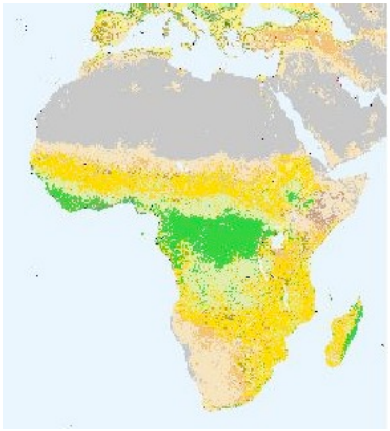


Landsat (30 m)

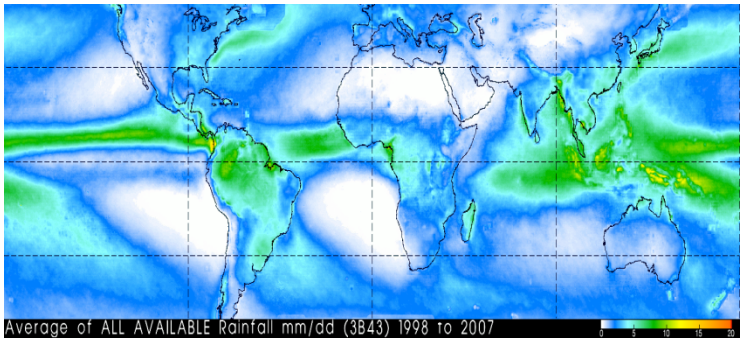
NASA Satellite Measurements with Different Spatial Resolutions

Landsat Image of Philadelphia
Spatial resolution: 30 m

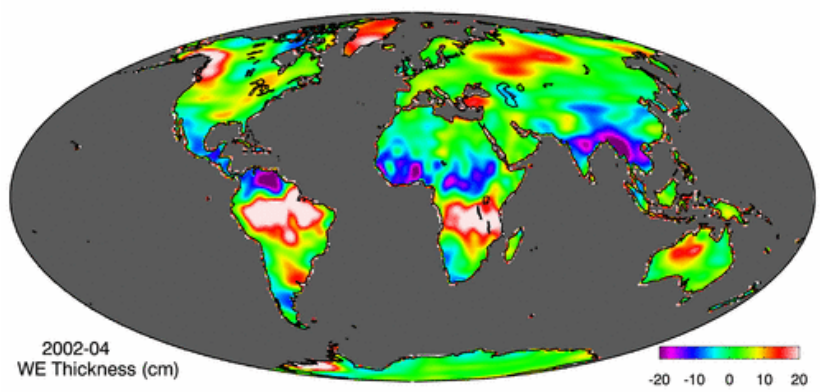
Land Cover from Terra/MODIS:
Spatial resolution: 1 km²
(From: http://gislab.jhsph.edu/)



Rain Rate from TRMM
Spatial resolution: 25 km²

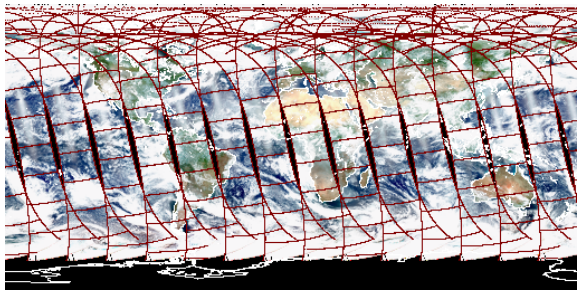


Terrestrial Water Storage Variations from GRACE: Spatial resolution: 150,000 km² or coarser (Courtesy: Matt Rodell, NASA-GSFC)

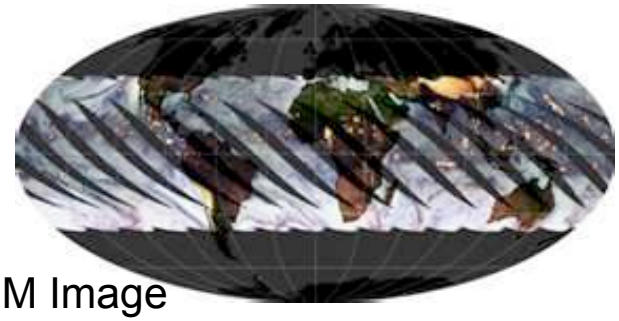


Spatial Coverage and Temporal Resolution

- **Polar orbiting satellites:** global coverage - but one to two or less measurements per day per sensor. Orbital gaps present. Larger Swath size, higher the temporal resolution.
- **Non-Polar orbiting satellites:** Less than one per day. Non-global coverage. Orbital gaps present. Larger Swath size, higher the temporal resolution.
- **Geostationary satellites:** multiple observations per day, but limited spatial coverage, more than one satellite needed for global coverage.



Aqua ("ascending" orbit) day time

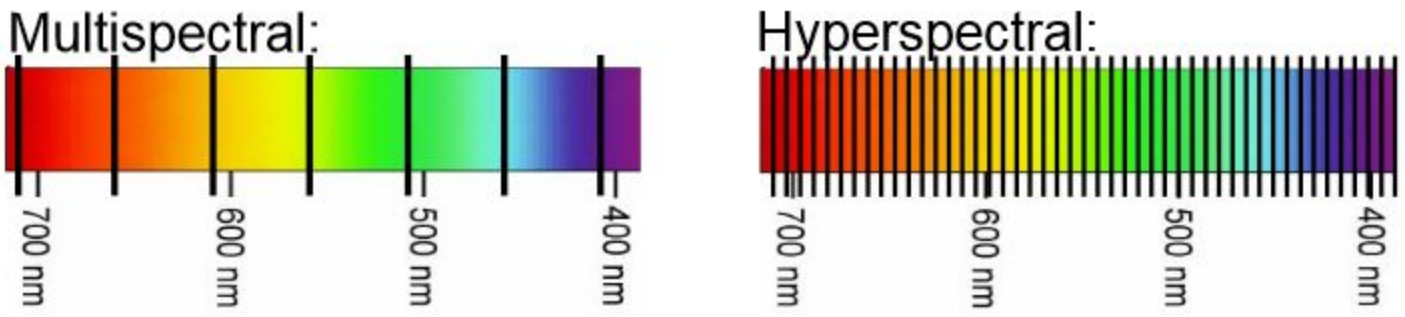


TRMM Image

GOES Image

Spectral and Radiometric Resolution

- **Spectral Resolution:** The number and width of spectral channels. More and finer spectral channels enable remote sensing of different parts of the Earth's surface



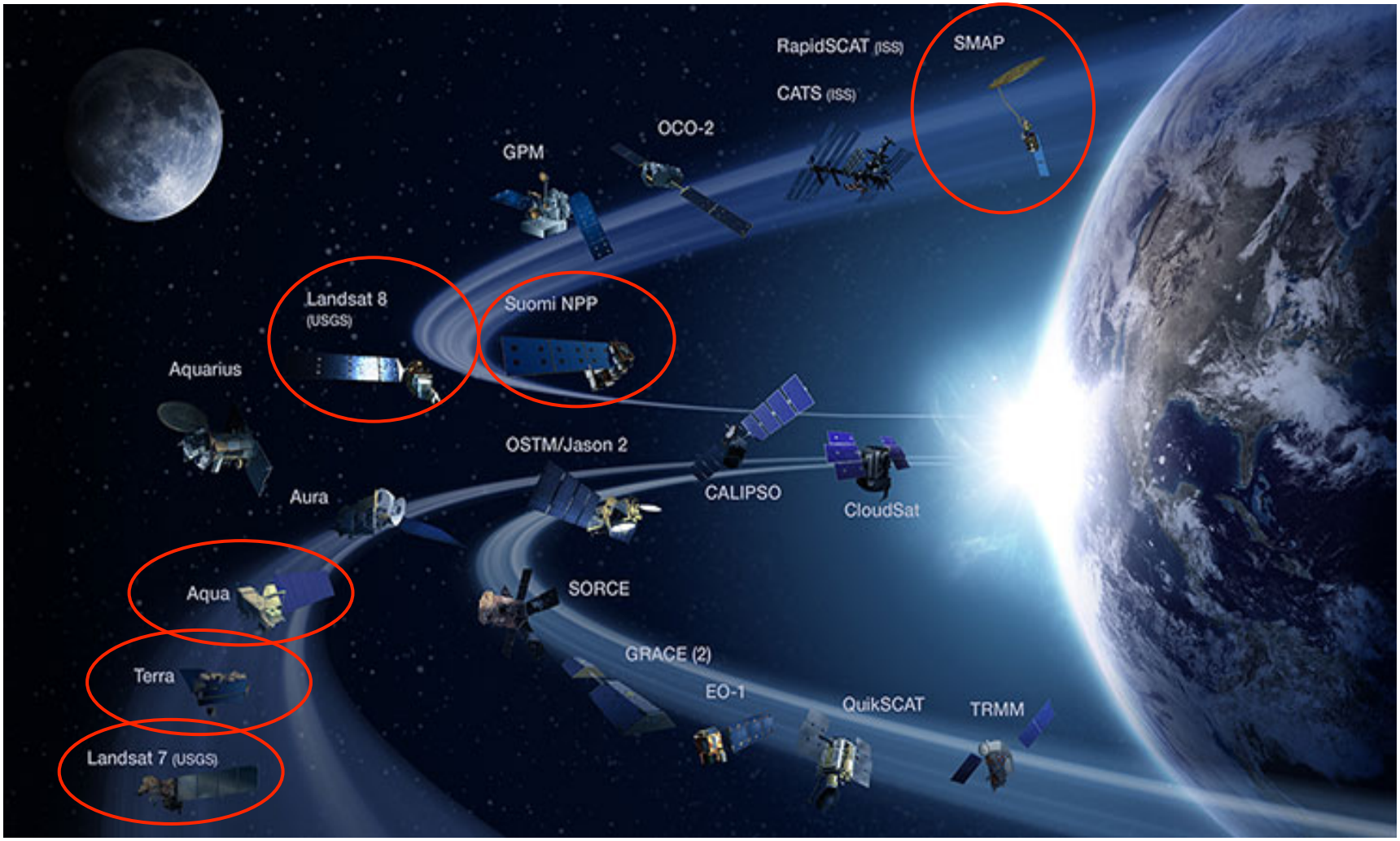
- **Radiometric Resolution:** Remote sensing measurements represented as a series of digital numbers – the larger this number, the higher the radiometric resolution, and the sharper the imagery.

Remote Sensing Observations: Trade-Offs

- It is very difficult to obtain extremely high spectral, spatial, temporal and radiometric resolution at the same time
- Several sensors can obtain global coverage every one – two days because of their wide swath width
- Higher spatial resolution polar/non-polar orbiting satellites may take 8 – 16 days to attain global coverage
- Geostationary satellites obtain much more frequent observations but at lower resolution due to the much greater orbital distance
- Large amount of data with varying formats
- Data applications may require additional processing, visualization and other tools

NASA Satellites and Sensors for Wildfire Management

NASA Satellites for Wildfire Management



NASA Satellites for Wildfire Management

Satellite	Sensor(s)	Dates	Spatial Resolution
Landsat 1-3	MSS	1972 - 1983	80 meter
Landsat 4 and 5	Landsat TM	1982 - 2013	30 m (120 m thermal band)
Landsat 7	Landsat ETM+	1999 - present	15 m panchromatic, 30 m multispectral, 60 m thermal
Landsat 8 (LDCM)	Operational Land Imager (OLI), Thermal Infrared Sensor (TIRS)	2013 - present	15m panchromatic; 30m multispectral; 100m thermal
Terra, Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	2000 - present	250 – 5600 meter
Terra	ASTER	2000 - present	15-90 meter
EO-1	Hyperion, Advanced Land Imager (ALI)	2000 - present	10-30 meter
Suomi NPP	Visible Infrared Imager Radiometer Suite (VIIRS)	2013 - present	375-750 meter
SMAP	Soil Moisture Active Passive	2015 - present	3 km

Products Derived from NASA Satellites for Wildfire Management

- **Pre-Fire Mapping**
  - Vegetation density and extent
  - Soil Moisture/Drought severity
  - Topography
- **Active Fire Mapping**
  - Total area currently burning
  - Fire Radiative Power (FRP) using thermal bands
- **Post-Fire Mapping**
  - Total area burned
  - Burn severity
  - Post-fire vegetation regrowth (NDVI)

Coming up next week!

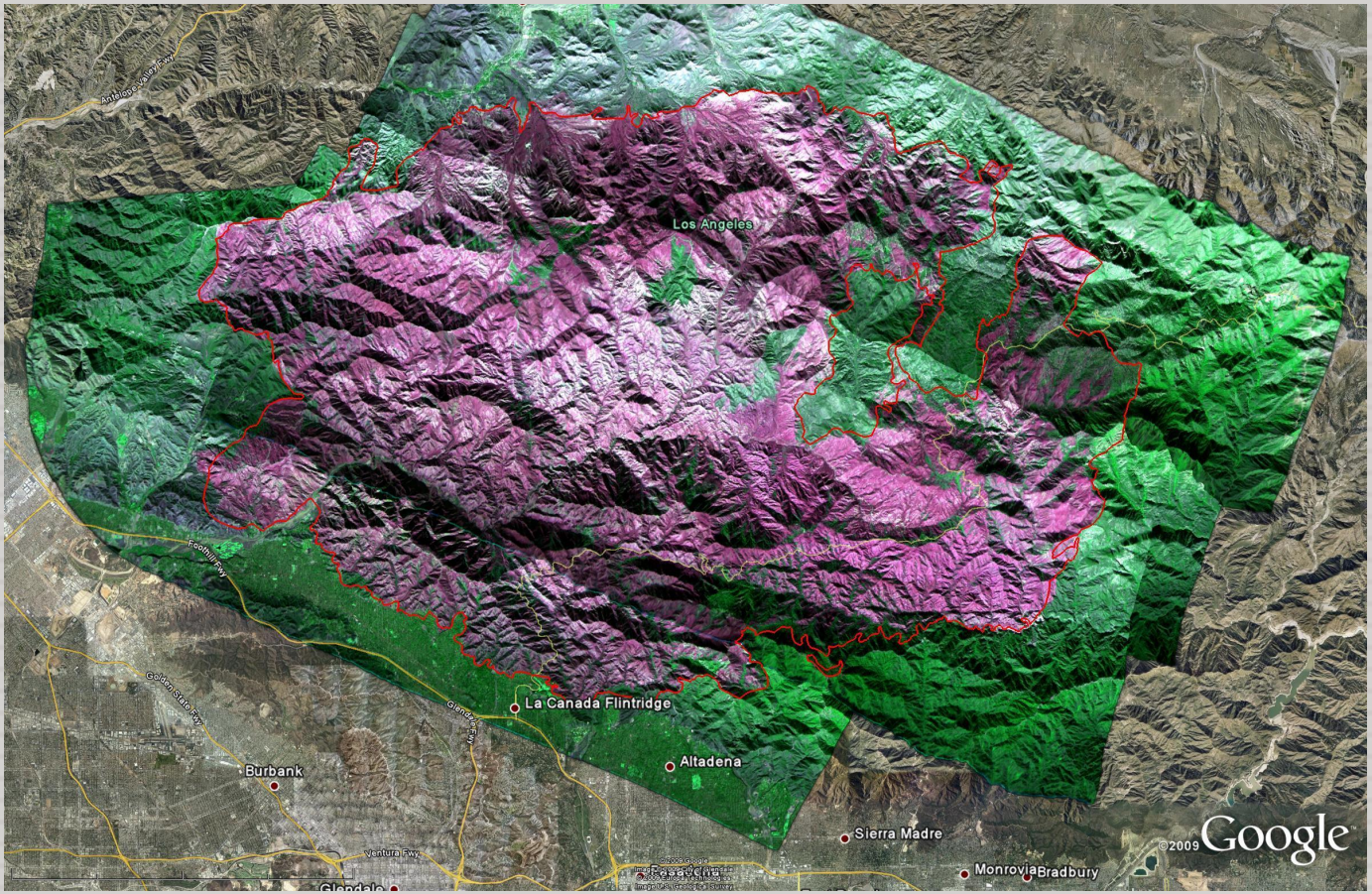
Week 2: Satellite and aircraft platforms for wildfire applications

Important Information

- One lecture per week – every Tuesday from March 31 to April 28 (11:30 AM – 12:30 PM EST)
- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: https://arset.gsfc.nasa.gov/disasters/webinars/introduction-remote-sensing-wildfire-applications
- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET wildfire webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com
- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

Station Fire, 2009.

NASA's Autonomous Modular Sensor, collected this post-fire Burned Area Emergency Rehabilitation, or BAER, image on Nov. 19, 2009. (NASA Image)



Thank You!!

Cindy Schmidt

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